REMARKS

This timely filed Reply is responsive to the Office Action mailed July 25, 2005. Claims 1-25 were pending at the time of the Office Action. All 25 claims were rejected in the Office Action.

A restriction requirement was imposed via telephone resulting in the Undersigned's verbal election to select claims 1-25 drawn to a coating and a non-toxic biofouling preventative system to prosecute, and to withdraw from consideration claims 26 and 27 drawn to a pump. As requested, Applicants herein confirm this election in this Reply. This election is made without traverse.

Several drawings have been rejected due to shading issues. Specifically, figures 2a, 2b, 3, 4a, 6, 8, and 9 were rejected based on light shading. Applicants have provided replacement drawings herewith for these rejected figures.

In this Reply, no claims have been amended. As noted above, claims 26 and 27 have been withdrawn. No new matter has been added.

Before reviewing the cited art, Applicants will first review the claimed invention recited in claim 1. Claim 1 recites a dynamic polymer-based coating, comprising:

at least one patterned polymeric layer for attachment to a surface, said polymeric layer including at least one electrically conducting polymer, wherein a contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction.

As noted in paragraph 33 of the application, upon application of an electrical bias to the polymer coating relative to another electrochemically active material (counter electrode) sufficient to oxidize or reduce the polymer in the presence of a suitable electrolyte, the polymer layer undergoes oxidation or reduction which results in a change in its surface properties,

including surface energy, surface tension, modulus and contact angle. Dimensional (volume) changes also generally result as a result of the oxidation or reduction.

As noted in paragraph 39 of Applicants' specification:

Exemplary electrically conducting polymers that can generally be used with the invention include PPy, polythiophene, and PPP, and their derivatives. These polymers can all be stimulated to undergo reversible physical changes in volume, surface energy and related properties, color, and light emission. In the case of PPy, a volume change of about 1-3% longitudinally and about 35% in thickness on a bound surface can be induced by electrochemically switching (redox cycling) the material between its oxidized (swollen) and reduced (contracted) forms. This large volume change induced during redox cycling will generally be accompanied by changes in the surface energy and related properties of the PPy comprising layer.

On page 9, paragraph 30 of Applicants' specification the phrase "electrically conducting polymer" is defined as follows:

As used herein, the phrase "electrically conducting polymer" refers to a polymer which provides a room temperature electrical conductivity of at least 0.1 S/cm, preferably at least 1 S/cm, such as 10 S/cm, such as 20 S/cm, 40 S/cm, 100 S/ cm, 200 S/cm or 1,000 S/cm.

In contrast, a dielectric (synonymous with electrically insulating) material is <u>not</u> electrically conductive, having an electrical conductivity of $< 10^{-6}$ S/cm as noted in Applicants' paragraph 31 which defines the generally accepted electrical conductivity boundary between a dielectric and a semiconducting material:

In the case of composite polymers, the composite material will have a lower electrical conductivity as compared to the electrically conductive polymer. The electrical conductivity of the polymer composite is at least that of a semiconductor, being at least 1×10^{-6} S/cm at room temperature.

Another element of claim 1 relates to the electrochemically active nature of the electrically conductive polymer layer. Specifically, amended claim 1 recites "wherein a contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction".

"Substantially increases or decreases" in the contact angle upon oxidation or reduction is defined in Applicants' specification in paragraph 34 as follows:

> Because of the relative ease of measurement and quantification, contact angle will be generally used herein to describe the dynamic changes electrochemically induced in the polymeric layer. As used herein, a substantial increase or decrease in contact angle refers to a change in contact angle between the charged and uncharged states of the polymer of at least 8 degrees, preferably at least 12 degrees, and more preferably at least 16 degrees, such as 20 degrees.

As noted in claim 2, the "polymer layer substantially expands or contracts in at least one direction upon at least one of said oxidation and reduction". "Substantially expands or contracts" is defined in paragraph 35 as:

> As defined herein, the phrase "substantially expands or contracts" relative to the polymeric layer refers to an expansion or contraction in at least one dimension, such as the height or width, of features comprising the polymeric layer of at least 1 %, and preferably at least 5 %, and more preferably at least 10 %.

Now turning to the cited art, claims 1-3, 7, 16-20 and 24 were rejected under 35 U.S.C. § 102(b) as being anticipated by Wooden et al. (US 4,297,394). Regarding Wooden, the Examiner asserts that:

Wooden et al 394 discloses a dynamic polymer-based coating, comprising at least one patterned polymeric layer 416, 416' for attachment to a surface 410, said polymeric layer including at least one electrically conducting polymer as disclosed in column 4, lines 40-44, wherein a contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction by vibration of the film of polymers 416, 416'.

The vibration of the polymeric layer leads to the layer substantially expanding or contracting in at least one direction upon at least one of said oxidation and reduction. Wooden et al 394 also discloses a non-toxic biofouling preventative system comprising a polymer-based coating 416, 416', 418 disposed on a subsurface of a boat or ship 310, said coating comprising a polymeric layer 416, said polymeric layer 416 including at least one electrically conducting polymer as disclosed in column 4, lines 40-44, and a power supply 320 for supplying a dynamic electrical signal to said polymeric layer, wherein a contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction responsive to said dynamic signal by vibration of the polymeric layers.

The coating of Wooden et al comprises a pattern of a plurality of , comprising at least one patterned polymeric layer 416, 416' for attachment to a surface 410, said polymeric layer including at least one electrically conducting polymer as disclosed in column 4, lines 40-44, wherein a

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micro scale or nanoscale features. Such features can any of the microscopic particles making up the layers.

The coating of Wooden et al 394 is a polymer composite, said composite including at least one non-electrically conducting polymer 416 mixed with said electrically conducting polymer, which is the cement discussed in column 4, lines 40-44.

In Wooden et al 394 the polymeric layer is a patterned polymer layer, the pattern being provided by layer 416, layer 418 and layer 416'.

Applicants respectfully disagree with much of what is asserted above regarding Wooden. Wooden is entitled "Piezoelectric polymer antifouling coating and method of use and application". Wooden discloses an antifouling coating with method of use and method of application on marine structures in the form of a film containing *piezoelectric polymer material.* When electrically activated with an alternating voltage the piezoelectric polymer material vibrates at a selected frequency to present a surface interfacing with water which is described as being inhospitable for attachment of vegetable and animal life including free-swimming organisms thereby discouraging their attachment and their subsequent growth thereon. In that the piezoelectric surface vibrates in response to the applied AC bias, Wooden's piezoelectric coating does function as a dynamic coating.

However, Wooden does not disclose or suggest, and in fact teaches away, from electrically conducting polymers. Piezolectric materials are by definition dielectrics, otherwise they cannot provide the required transduction between vibrational and electrical energy. The piezoelectric effect produces a voltage between surfaces of a solid dielectric (a dielectric is the opposite of an electrically conducting substance) when a mechanical stress is applied to it, or

when a voltage is applied across certain surfaces of a solid that exhibits the piezoelectric effect, the solid undergoes a mechanical distortion.

The voltage transduction effect to provide mechanical distortion is used by Wooden. The piezoelectric effect, discovered by Pierre Curie in 1883, is exhibited by certain dielectric crystals, such as quartz, Rochelle salt, lead titanate zirconate ceramics (e.g. PZT-4, PZT-5A, etc.), barium titanate, and polyvinylidene flouride (a polymer film). In col. 3 lines 8-9, Wooden specifically recites polyvinylidene fluoride (PVDF) as the preferred piezolectric. Applicants have attached a datasheet from Afton Plastics for PVDF showing the electrical conductivity of PVDF to be about 10^{-14} to 10^{-15} S/cm (1/volume resistivity (in ohm-cm)). Applicants have also provided a 7 page portion of an Internet posted course entitled "Piezolectric transducers" posted by the University of Washington which was downloaded by Applicants on October 14, 2005 (attached). The first paragraph of "Piezolectric transducers" is copied below for convenient reference:

> Transducers that make use of the piezoelectric effect are widely used. These may be used to measure force by changing applied force to electrical energy or to generate force or movement from an electrical input. *To understand the piezoelectric effect, we must first consider the dielectric properties of materials. These materials are all electrical insulators - they do not conduct current.* (italics for emphasis)

Similarly, as noted below the schematic representation of dielectric polarization on page 1 of the downloaded material, "Because the material does not [electrically] conduct, the interior of the material now has a potential gradient". This gradient is clearly required for the piezoelectric effect.

The dielectric (electrically insulating) aspect of a piezoelectric is thus required to permit electrical energy to be stored in an electrical field based on charge separation, such as depicted in the schematic representation of dielectric polarization on page 1 of the downloaded material.

Wooden's piezoelectric polymers are PVDF, PVF, and cellulose acetate buterate (col. 3, lines 15-18). These are all known to be dielectric materials which have an electrical conductivity at room temperature of substantially less than 10^{-6} S/cm, with PVDF as noted above being about 10^{-14} to 10^{-15} S/cm. Col. 3, lines 11-18 discloses this aspect of Wooden:

> Coating 312 is comprised of a film of plural layers of piezoelectric polymer such as poly(vinylidene fluoride) in the form of a film adhered by a conductive cement (not illustrated) to the surface of structure 310 in electrical contact therewith. Other piezoelectric polymeric materials such as polyvinyl fluoride or cellulose acetate butrate, for example, may be used in the coating.

The only electrically conductive material disclosed by Wooden is a silver filled epoxy tape (col. 4, lines 40-44) which is used exclusively to cement the piezolectric (dielectric) to the surface to be protected ((col. 4, lines 40-47). The electrical conductivity of the tape is provided by the *metallic* silver particles since epoxy polymers are well known to be dielectric materials.

Applicants have thoroughly searched Wooden and cannot find any disclosure regarding contact angle (or anything related), nor the electrochemical processes of oxidation or reduction (or anything related). Piezoelectric materials do not redox, instead, as noted above and taught by Wooden, when electrically stimulated, they simply vibrate.

Applicants have identified below at least three claimed limitations recited in claim 1 that are not disclosed or suggested by Wooden:

i) <u>Wooden does not disclose or suggest Applicants' claimed "patterned polymeric layer"</u>

According to the Examiner, Wooden discloses Applicants' claimed patterned polymer layer:

> In Wooden et al 394 the polymeric layer is a patterned polymer layer, the pattern being provided by layer 416, layer 418 and layer 416'.

Applicants respectfully disagree with the Examiner's assertion that Wooden's polymer layer is a patterned layer, and can find no such teaching to support such an assertion. In fact, the opposite is taught. Piezoelectric layers 416 and 416' are disclosed by Wooden to be formed by simple spraying (col. 5, lines 13-20) to form a "continuous sheet". Moreover, Wooden teaches the piezolectric layer must be secured continuously over the water facing surface without "uncovered areas" otherwise "alternate rows of fouled and unfouled rows will result" as disclosed in col. 4, lines 22-34 (copied below):

> To define an effective coating for a marine structure, such as a ship's hull, it is important that the film be secured continuously over substantially the entire outer or water facing surface. Continuous coating may be either uninterrupted or made up of discrete joining units covering the whole. The film vibrates at its water interface to render its surface inhospitable. A film in strips over a surface leaving uncovered areas as shown in U.S. Pat. No. 4,070,185 is not effective in preventing fouling on such uncovered areas. Piezoelectric polymer film is not sufficiently strong to cause effective hull vibrations between the strips to prevent fouling. Alternate rows of fouled and unfouled rows will result.

ii) <u>Wooden does not disclose or suggest Applicants' claimed "electrically conducting polymer"</u>

The Examiner asserts that Wooden discloses Applicants' claimed "polymeric layer including at least one electrically conducting polymer as disclosed in column 4, lines 40-44". Applicants respectfully disagree and can find no such teaching. Applicants have copied this excerpt (line 39 up to line 47) of Wooden for easy reference:

A thin layer of electrically conducting cement (not illustrated in FIG. 1), such as a silver filled epoxy which polymerized at around room temperature, is applied evenly over the cleaned surface by brushing or spraying. Before the cement (now defining an inner layer) hardens appreciably, the first layer of piezoelectric polymer 316 is applied over it and smoothed into position so as to adhere evenly over the structure.

The above passage refers to Figure 3. The disclosed silver filled epoxy layer is the conducting cement that is placed between the piezoelectric polymer 316 and the structure to be protected 310 (e.g. boat hull). Epoxy is a dielectric polymer. Thus, the silver epoxy layer is a

polymeric layer including at least one *electrically conductive metal,* but does not include Applicants' claimed electrically conductive polymer. Moreover, Wooden's polymeric layer including at least one electrically conductive metal (silver epoxy) is separate from (and is thus not intermixed) with piezoelectric layer 316 for which it provides bonding to.

As demonstrated above, a piezoelectric must be a *dielectric* (electrically insulating) crystalline material to provide transduction between mechanical and electrical energy. Dielectric materials are the antithesis of electrically conducting materials. Accordingly, although Wooden discloses an electrically conductive attachment layer in column 4, lines 40-44 that includes a polymer, this layer clearly does not include the claimed "electrically conducting polymer".

iii) <u>Wooden does not disclose or suggest Applicants' claimed "contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction</u>"

The Examiner asserts that Wooden discloses "wherein a contact angle of said polymer layer substantially increases or decreases upon at least one of oxidation and reduction by vibration of the film of polymers 416, 416'". Applicants respectfully disagree with this assertion.

Layers 416 and 416' are piezoelectric layers. As disclosed on col. 3, lines 29-35, the alternating current waveform induces vibration of the piezo film 316 and 316'.

> An alternating current of selected frequency and wave form is applied from source 320 across electrode 318 to electrode 318' and structure 310, which acts an electrode, for activating the piezoelectric polymeric material layers therebetween for causing their vibration and vibration of the film at a resonance frequency in a direction substantially normal to the water interface.

The vibrations are disclosed by Wooden to "cause the coating to [flex] flick in a manner for throwing off would-be attaching bodies". (col. 3., lines 47 and 48).

As noted above, Applicants have searched Wooden and cannot find mention of any contact angle changes or oxidation or reduction processes in Wooden. Applicants acknowledge that piezoelectrics can provide some contact angle change, particularly if the layer is thin and the voltage is high. However, the required voltage to induce a measurable contact angle change in piezoelectrics is generally reported in the range of 100-200V. Too high a voltage can result in destructive dielectric breakdown. Since actuation and contact angle changes in piezoelectrics are not related, actuation (movement) can be provided without a change in contact angle. Accordingly, Wooden teaches away from operating conditions and layer thickness that would provide a contact angle change as it can render the system inoperable and is not required for actuation.

Even assuming *arguendo* that Wooden's piezolelectric changes contact angle, Applicants' claimed invention recites "a contact angle of said polymeric layer *substantially increases or decreases* upon at least one of oxidation and reduction".

"Substantially increases or decreases" is defined in Applicants' specification on page 10, lines 17-20 as:

As used herein, a substantial increase or decrease in contact angle refers to a change in contact angle between the charged and uncharged states of the polymer of at least 8 degrees, preferably at least 12 degrees, and more preferably at least 16 degrees.

Accordingly, even if Wooden achieves some incidental contact angle change for the piezolectric, it would clearly not be Applicants' claimed "substantial increase or decrease in contact angle" as defined above. Moreover, it is well known to those having ordinary skill in the art that piezoelectrics, such the piezoelectrics disclosed by Wooden, are dielectric materials which clearly cannot undergo the electrochemical processes of oxidization or reduction because they are by definition dielectric materials. Accordingly, even if some incidental contact angle change for the piezolectric is provided by Wooden, The change is not "upon at least one of

oxidation and reduction". Therefore, Wooden does not disclose or suggest Applicant's claimed "contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction".

Accordingly, since Wooden does not disclose or suggest Applicants' claimed (i) "patterned polymeric layer", ii) "electrically conducting polymer", and iii) "contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction", Applicants submit that claim 1 and its respective dependent claims are clearly patentable over Wooden.

Claim 16 recites a non-toxic biofouling preventative system, comprising:

a polymer-based coating disposed on a subsurface of a boat or ship, said coating comprising a polymeric layer, said polymeric layer including at least one electrically conducting polymer, and

a power supply for supplying a dynamic electrical signal to said polymeric layer, wherein a contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction responsive to said dynamic signal.

Since claim 16 recites the same i) "patterned polymeric layer", ii) "electrically conducting polymer", and iii) "contact angle of said polymeric layer substantially increases or decreases upon at least one of oxidation and reduction" recited in claim 1, for reasons noted above relative to claim 1, Applicants submit that claim 16 its respective dependent claims are clearly patentable over the cited art.

Several dependent claims are believed to recite independently patentable limitations. For example, claim 2 recites "said polymer layer substantially expands or contracts in at least one direction upon at least one of said oxidation and reduction". Claim 4 recites " said plurality of

features provide a roughness factor of at least 2". The roughness factor (R) as defined in the application is defined as the ratio of actual surface area (Ract) to the geometric surface area (Rgeo); R = Ract/Rgeo). Claim 7 recites "said polymeric layer is a polymer composite, said composite including at least one non-electrically conducting polymer mixed with said electrically conducting polymer". Claim 11 (dependent on claim 10) recites "said electrode layer is patterned, said pattern comprising a plurality of microscale or nanoscale features", while claim 12 (dependent on claim 11) recites "wherein said [electrode layer] pattern is interdigitated". Wooden does not disclose or suggest any of these limitations.

Applicants have made every effort to present claims which distinguish over the cited art, and it is believed that all claims are clearly in condition for allowance. However, Applicants invite the Examiner to call the undersigned if it is believed that a telephonic interview (direct line (561) 671-3662) would expedite the prosecution of the application to an allowance. Although no fee is believed to be due, the Commissioner for Patents is hereby authorized to charge any deficiency in fees due or credit an excess in fees with the filing of the papers submitted herein during prosecution of this application to Deposit Account No. 50-0951.

Respectfully submitted,

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